Volume 110
Article 06

ISSUE PAPER

OPERATION OF COMPENSATION HATCHERIES WITHIN A CONSERVATION FRAMEWORK

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November 1993

ISSUE

What is the best use of compensation hatcheries located in natural production areas for threatened salmon, and the fish returning to these facilities?

BACKGROUND

Five of Idaho's chinook hatchery programs are located in important natural production areas for spring and summer chinook salmon listed for recovery under the auspices of the Endangered Species Act (ESA). Sawtooth Hatchery includes the upper Salmon River and East Fork Salmon River programs, and McCall Hatchery the upper South Fork Salmon River program. Both hatcheries are part of the Lower Snake River Compensation Plan (LSRCP). Pahsimeroi and Rapid River hatcheries are part of The Idaho Power Company (IPC) mitigation. These hatcheries were constructed to compensate for fish losses from hydropower development on the lower Snake River (LSRCP) and Hells Canyon reach of the Snake River (IPC). Broodstock for Rapid River Hatchery was derived from chinook that are not native to the Rapid River drainage. This distinction makes Rapid River Hatchery inappropriate for much of the approach outlined in this issue paper. Broodstocks for the other four hatchery programs were derived primarily from local stock endemic to the natural production areas where the hatchery programs operate. These stocks may also include genetic material from non-endemic chinook resulting from stock transfers (Bowles and Leitzinger 1991).

The approach for mitigation was to spawn and rear a portion of the historically productive local broodstock to produce a large number of smolts to compensate for lost smolt production (IPC) or reduced smolt-to-adult survival (LSRCP) from hydropower development. Annual broodstock management included retaining 67% of unmarked adults for hatchery production, up to escapement needs, and passing 33% of unmarked adults to spawn naturally. This strategy was implemented in an attempt to reduce domestication effects and maintain long term fitness of the locally evolved stock. All marked adults (0% to 25% of total) were retained and incorporated into the hatchery broodstock.

By the late 1980s it became evident that Snake River basin mitigation/compensation hatcheries were falling dismally short of mitigation objectives for chinook salmon (Herrig 1991). Even if significant improvements were made in fish health and husbandry, meeting mitigation expectations was highly unlikely until mainstem survival conditions were improved (Cannamela 1992). In addition, managers were concerned with continued erosion of natural production and the potential effects of these compensation programs on stock identity and natural productivity. Preliminary genetic monitoring studies have not detected obvious differences between hatchery and naturally reared fish (Waples et al. 1993, Marshall 1993), although pre-hatchery genetic information is not available. Analysis of spawning escapement data from before and after hatchery production began shows that more adults are returning to these production areas than would be expected without hatchery contributions (Appendix A). This hatchery benefit has only slowed the decline of total chinook production in the upper Salmon River, whereas in the upper South Fork Salmon River the hatchery benefit has actually increased total production. Although the hatchery programs are providing an adult-to-adult survival advantage, it was recognized that a greater emphasis needed to be put on the purely natural component of the local stock to insure its long term viability.

In response to this concern, additional conservation measures were implemented and natural production objectives became the driving force of compensation programs (Bowles and Leitzinger 1991, IDFG 1992). These programs utilize modified broodstock strategies, supplementation, naturally oriented rearing and release strategies, and intensive monitoring and evaluation to help meet conservation objectives. Beginning with brood year (BY) 1991, all hatchery chinook were externally marked prior to release. By 1995, all but 3-ocean returning adults will be distinguishable into three groups: **naturally** reared fish (unmarked), hatchery reared fish for **supplementation** (pelvic fin clip) and hatchery reared fish for **reserve** production (adipose fin clip).

OBJECTIVES OF COMPENSATION HATCHERIES

Chinook hatcheries in Idaho were constructed with the goal of using artificial production to provide harvest opportunities lost through hydropower development. Restoring fisheries remains an important product of recovery (Idaho Code, Title 36) Managers now recognize that the assumed mitigation benefits expected from these upper basin hatcheries cannot be realized until juvenile chinook survival through the mainstem hydrosystem is improved (Petrosky and Shaller 1993).

Interim conservation objectives for these areas with mitigation hatcheries are to utilize natural and hatchery production to maintain as much locally evolved genetic material as possible until system improvements allow for legitimate recovery (IDFG 1992). **The overriding priority is recovery of sustainable naturally reproducing chinook populations.** This is not only vital to the preservation of the chinook species, but also the foundation for sustainable harvest opportunities in the future.

OPTIONS

There are several basic options regarding use of facilities and the three groups of returning adults in an attempt to meet conservation objectives.

1. Shut down hatchery facilities and allow all returning adults to spawn naturally.
2. Allow all unmarked fish to spawn naturally and retain all marked fish for hatchery production.
3. Utilize the hatchery to supplement naturally spawning fish, preserve genetic material and maintain viable populations.
4. Retain all fish for hatchery production.

Each of these options must meet the interim objective to maximize effective size of the locally evolved population. This objective has several facets: maximize the number of fish retaining local genetic characteristics, optimize utilization of natural spawning and rearing habitat, and minimize adverse impacts to adjacent populations.

Several basic assumptions must be met to minimize risk and successfully integrate hatchery and natural production systems.

- Hatchery reared fish have an adult-to-adult survival advantage over naturally reared fish.
- Mining of natural fish for hatchery broodstock does not reduce the effective population size below critical level or result in loss of within population diversity.
- Release of hatchery reared fish does not swamp the natural target population and reduce within population diversity or alter population identity, and does not swamp non target natural populations through straying and loss of among population diversity.
- Hatchery practices do not promote genetic drift and artificial selection, which may cause loss of within population diversity and population identity.

- Hatchery practices and products do not impair the natural behavior or health of the locally evolved stock.

- Monitoring and evaluation has adequate power to resolve critical uncertainties, contain risks and allow managers to adapt the program accordingly.

APPROACH

Sustainable recovery of the number and inherent diversity of naturally reproducing chinook is only possible by improving mainstem juvenile migration conditions (Petrosky and Shaller 1993). Other options, such as artificial propagation and habitat improvement, may be important but are limited in potential benefits and focus on enhancing only a small portion of the natural diversity structure (Kapuscinski et al. 1991, Bowles 1992, RASP 1992).

Within this constraint, managers have recognized the potential benefits supplementation may provide as an interim measure to stem the decline of naturally reproducing populations (CBFWA 1990, CRITFC 1990, IDFG 1992, NPPC 1993). Existing mitigation/compensation facilities provide a unique opportunity to assess the utility of supplementation. Risks are more manageable and acceptable in these areas because natural populations have already been influenced by hatchery production.

We believe using these compensation/mitigation hatcheries in a manner that successfully integrates natural and artificial production is the best option for meeting conservation objectives. This decision is based on the assumptions that the criteria listed above for successful integration can be met, and that all three groups of chinook salmon returning to these production areas are important to recovery (i.e., locally evolved genetic material is relatively intact and represented in both hatchery and naturally reared fish).

The unmarked naturally reared group is our top priority, and afford the highest protection and care. Our second priority is the supplementation fish reared in a hatchery to enhance natural production. Natural fish make up at least half of this group's parents, and they are genetically similar to the unmarked group. The last group of fish are the "reserve" fish, which are third in priority but still important. This group is the closest genetic material available, should the natural and supplementation fish collapse. The reserve bank may play a vital role in avoiding severe bottlenecks from stochastic events and natural variability.

How do we best utilize these three groups to attain optimal conservation benefits without causing unacceptable risks? As stated, the primary emphasis should be placed on the unmarked naturally reared adult returns. This is the target group and true measure of recovery success. Genetically conservative criteria should be established to protect these fish and guide supplementation efforts. These criteria and the response of this group of fish should drive the entire program, -- not hatchery capacity, egg availability or harvest considerations.

Management of supplementation fish should not compromise these natural production criteria. The number of natural fish determine how many supplementation fish are integrated into the naturally rearing and reproducing group. The number of natural adults also determines the size of the supplementation broodstock, which should be comprised of at least 50% natural fish. This supplementation broodstock is the "bank" used to rebuild the naturally spawning group, but at a rate that avoids swamping (e.g., "50:50 rule", hatchery reared fish spawning or rearing in the natural habitat should not exceed the number of natural fish).

The third group of fish serves as a "reserve bank" to preserve locally evolved genetic material and augment natural production during severe bottlenecks when the natural and supplementation groups drop below established thresholds for population viability. This group, which has primarily hatchery-by-hatchery (HxH) parental crosses, is only useful in this role if it maintains genetic and ecological similarity to the local naturally spawning group, and does not compromise adjacent naturally spawning populations from straying. Fish culture and monitoring activities should all focus toward meeting these demands.

MANAGEMENT OF FISH GROUPS

We have developed criteria to guide the management of these three important groups of fish (Table 1). These criteria reflect current conservation concepts and standards within the Columbia River Basin (CBFWA 1990, Kapuscinski et al. 1991, RASP 1992, Hard et al. 1992, NPPC 1993), but are understandably conceptual. Refinement of these standards through quantitative modeling and experimentation is necessary but, until this is done, we have chosen to err on the side of conservancy.

Table 1. Conservation framework for management of three groups of chinook salmon returning to compensation hatcheries in Idaho.

FISH GROUP		
	Hatchery-Reared	
Natural-Reared	Supplementation	Reserve
Purpose		
Preserve natural productivity and diversity as unique components of chinook species, and foundation for harvest opportunities	Increase natural production of local populations without impairing natural productivity	Maintain/enhance effective size of local genetic material and augment natural production when at critical levels future
Priority		
First	Second	Third
ESA Designation		
Listed	Listed	Listed
Adult Allocation		
≥67% allowed to spawn naturally	Fish allowed to spawn naturally cannot exceed number of naturally-reared spawners	None allowed to spawn naturally, unless natural and supplementation spawners are below critical threshold
≤33% retained for supplementation broodstock	Remainder of fish retained in hatchery for supplementation broodstock	Remainder retained for "reserve bank" broodstock
Broodstock		
≥50% natural origin	≥ 50 % natural origin	Nearly 100% hatchery origin
≤50% hatchery origin (supplementation fish)	≥50% hatchery origin (supplementation fish)	Small portion (3%?) natural origin, to avoid genetic drift Note: male natural gametes may be adequate
Spawning		
Natural	Non-selective for size, age, origin	Non-selective size, age
	1:1 sex ratio	1:1 sex ratio
	Factorial crosses, if necessary	Factorial crosses, if necessary
Rearing		
Natural	Separate from reserve fish	Separate from supplementation fish
	Natural-oriented techniques	Natural-oriented techniques
	Natural growth schedule	Natural growth schedule
	Innoculation and treatment	Innoculation and treatment
Marking		
Up to 2,000 PIT tags in parr, presmolts, or smolts	100% pelvic fin clipped	100% adipose fin clipped
	≥500 PIT tags	Portion CWT for U.S. v. Canada
		≥ 500 PIT tags

Table 1. Continued.

Natural-Reared	Hatchery-Reared: Supplementation	Hatchery-Reared: Reserve
Releases		
N/A	Volitional or timed to coincide with natural emigration	Volitional or timed to coincide with natural emigration
	Off-station releases scattered throughout target natural production areas.	Acclimation where feasible
	Parr releases cannot exceed natural parr numbers and carrying capacity	Smolt or fall presmolt stage
	Fall presmolt and smolt releases should represent adult equivalents expected from natural production	
Harvest		
None targeted	None targeted	Utilized as a tool to maintain spawning escapement below thresholds established for straying and rearing criteria
Monitoring and Evaluation		
Genetics	Genetics	Same as supplementation fish, except: Adult escapement to Lower Granite Dam to predict rack returns
Health	Health	
Juvenile abundance/density	In-hatchery performance and survival	
Juvenile distribution and habitat utilization	Release characteristics: Size Location/date Method	
Emigration characteristics	Post-release behavior and distribution	
Adult run/spawner characteristics: Number Age structure Sex ratio Run timing Spawning distribution and timing	Adult run/spawner characteristics Straying into non-target areas	
Survival characteristics: Prespawn Egg to parr Parr to emigrant Emigrant to smolt Smolt to adult	Post-release survival characteristics: Release to smolt Smolt to adult Prespawn	

Naturally Spawning Adults

The role of natural fish is to preserve the natural productivity and diversity that make these locally evolved fish vital to the perpetuation of the chinook species and future harvest opportunities.

– At least 67% of naturally produced adults (unmarked) from throughout the run should be allowed to spawn naturally. This minimizes the risk of "mining" and subsequent loss of effective natural spawners below acceptable levels.

– At least 50% of adults spawning naturally should be of natural origin (unmarked). Adult returns from the supplementation group can be used to make up the remaining 50% of fish spawning naturally.This criteria minimizes the risk of "swamping" and subsequent loss of within population diversity and population identity. This criteria should only be compromised when numbers of natural and supplementation fish fall below thresholds where risk of extinction from stochastic events or genetic bottlenecking overrides risk of swamping. In this situation, the 50:50 rule would be violated to maintain a minimum population level, utilizing fish from the genetically similar "reserve" bank.

- Harvest should never target naturally produced fish until recovery is secure.

Supplementation Fish

The role of these fish are to utilize the survival advantage gained in the hatchery to increase the number of fish available to spawn naturally. These fish will be integrated directly with the natural fish, so success is dependent on these fish remaining genetically and ecologically similar to the natural fish.

The number of fish reared for supplementation should be determined by natural fish escapement and the 50:50 rule to minimize risk of "swamping". If supplementation fish are released as parr, their numbers should not exceed the number of natural parr or rearing capacity of the habitat. If supplementation fish are released as smolts, their numbers should be designed to bring back only as many adults as anticipated from naturally reared fish.

- Spawning and rearing strategies should focus on minimizing genetic and behavioral divergence from the target population being supplemented.

    - At least 50% of the supplementation broodstock should be comprised of unmarked adults that were reared in the natural environment. The remaining 50% of the supplementation broodstock can be comprised of hatchery reared fish (marked). This criteria will help avoid domestication, genetic drift, and loss of effective population size.

    - Rearing strategies should be designed to circumvent random natural mortality events, but mimic selective natural mortality events.

- Release strategies should be designed to minimize first generation interaction and "swamping" effects (e.g., release at smolt stage, distribute releases throughout target natural production area, parr or presmolt releases should match natural fish size, good health).

- Harvest should not target these fish until recovery is secure.

Reserve Fish

The role of reserve fish is to maximize locally evolved genetic material available to recovery, and provide a reserve "bank" to augment natural production if levels drop below critical thresholds. This latter need may result from stalled recovery actions, stochastic environmental events, or natural variability. To serve this function, reserve fish must remain genetically and ecologically similar to the target population, and must be maintained at levels that will not adversely impact target and non target Dopulations through straying and interactions. The challenge is to maintain as much reserve as possible without genetic drift, inadvertent hatchery selection and domestication, and without harm to adjacent natural populations. This challenge is accentuated because the reserve group will be predominantly HxH crosses.

Minimize Genetic Drift

The reserve group currently has similar genetic and ecological characteristics as the target natural population. This similarity results from an inability to differentiate hatchery and natural returns and broodstock strategies promoting constant and thorough mixing. As marked fish return and differentiation becomes possible, risk of genetic drift also increases.

To avoid random genetic divergence, gametes from natural origin adults should be infused into the reserve group at a rate designed to maintain drift within acceptable detection limits. This rate of infusion can be quantified based on genetic monitoring of each group of fish. Initially, the rate should be quite low (<3%) because the groups are genetically similar. As multiple generations of reserve fish occur, the infusion rate will likely increase to maintain this similarity.

The rate of infusion to avoid genetic drift may determine the maximum number of reserve fish to propagate. Our top priority is natural fish and only a limited number of natural fish can be "mined" to maintain the integrity of the reserve fish. Innovative techniques, such as partial male spawning prior to release above the weir, may help reduce this constraint.

Avoid Domestication and Inadvertent Hatchery Selection

Natural oriented rearing techniques should be utilized to minimize inadvertent hatchery selection and avoid behavior modifications that may result in adverse interactions with natural fish (Cannamela 1993, RASP 1992, Bowles 1993). Our ability to culture fish to meet these specifications may also determine the maximum number of reserve fish to propagate (e.g., low density).

Minimize Adverse Interactions

Although maximizing effective population size is important, it is also vital to maintain numbers and quality of this reserve group at levels that will avoid harmful straying, disease transmission, and genetic and behavioral divergence.

To contain risk of straying, managers should:

1) establish acceptable straying rates based on genetic similarity, potential outbreeding depression, loss of among population diversity and population identity;

2) develop and incorporate release strategies that maximize return integrity (e.g., imprinting cues, acclimation, smoltification, etc.);

3) Monitor straying and limit production of reserve fish to maintain straying within specified limits.

To contain risks of disease transmission, health management should incorporate state-of-the-art prophylactic and therapeutic techniques. Strategies to contain risk of genetic and behavioral divergence were discussed above and include conservative broodstock management and natural oriented rearing techniques.

Management of Reserve Fish Numbers

Managing levels of reserve fish to avoid unacceptable risk to natural production is vital to the success of the program. Obviously, the upper limit of fish maintained in the reserve bank will not necessarily be determined by hatchery capacity. Quantifiable limits are currently lacking, but may be below facility capacities. Until uncertainties are better resolved, initial criteria should err on the side of the natural component and maintain conservative numbers of reserve fish.

Production can be managed to minimize surpluses in most years. Managing at levels that will never produce surpluses is risky and undesirable because of high annual variability in system productivity. Management contingencies must be in place to handle potential escapement surpluses of reserve fish that variable system productivity may cause.

One option for surpluses is to spawn all reserve fish and dispose of eggs in excess of established criteria. This approach is undesirable because it fails to remove surplus fish before straying effects occur.

Fisheries may be the most effective tool for managing spawning escapement of reserve fish. Fisheries can remove surplus fish prior to straying and thus keep straying rates into adjacent drainages at acceptable levels. This approach would also allow exercise of lawful harvest privileges and responsibilities during the recovery pr3cess. Harvest would be appropriate during years when returns of reserve fish are high enough to cause unacceptable risk from straying, hatchery rearing capacities, and criteria relating to fish quality and behavior.

This approach represents a substantial conceptual shift from the original mandate for construction of mitigation/compensation hatcheries. The shift is from managing production as a tool for harvest, to managing harvest as a tool for production. Although this represents a conceptual shift, in practice the shift is much less substantial. Severe system constraints (i.e, mainstem survival bottlenecks) have precluded legitimate harvest opportunities since 1978. Compensation facilities have typically operated in a conservation mode well below capacities, attempting to maintain the maximum number of adult chinook possible until system survival improvements are made.

UNCERTAINTIES

Successful utilization of harvest as a tool to manage production is dependent on several assumptions.

1. Run size of reserve fish can be predicted accurately and with enough sensitivity to implement harvest strategies.

2. Harvest can be selective for reserve bank fish.

3. Catch and release of natural and supplementation fish can be managed at low enough levels to avoid unacceptable prespawn mortality and behavioral changes (e.g., temporal or spatial shift in spawning).

4. ESA guidelines are flexible enough to accommodate harvest of listed fish, recognizing that lack of harvest during high return years may result in unacceptable risks to recovery. Note: Although predominantly HxH crosses, the reserve fish would be "listed" because of periodic incorporation of natural fish to avoid genetic drift.

   Federal regulations for conservation of threatened species may provide for direct take (16 USC, 1533 d). The Ninth Circuit Court upheld regulations which authorized "a carefully controlled and limited sport hunt of grizzly bears in designated geographical regions..." (Christy v. Hodel 857F.2d 1324, 1988). Permitting limited sport hunting in particular areas was consistent with the goal of conserving the species.

Numerous other uncertainties exist which preclude completely confident and risk free integration of compensation/mitigation programs into the recovery process. Some of these include:

- Can routing fish through a hatchery environment provide an adult-to-adult survival benefit over allowing fish to spawn and rear in the natural environment?

- Can spawning, rearing and release strategies be implemented to insure long term genetic and ecological similarity between hatchery and natural fish?

- How much and how frequent must natural genetic material be introgressed with reserve fish to avoid genetic drift?
- What are acceptable straying rates (as a percentage of local escapement) into non-target production areas?
- Can straying rates be maintained within acceptable levels by limiting production of the reserve fish and utilizing appropriate release strategies?

MONITORING AND EVALUATION

Monitoring and research should be designed and implemented to resolve these uncertainties and identify unacceptable risks. We believe the uncertainties and risks associated with this approach are manageable within a monitoring and evaluation program so that implementation can proceed. This feedback loop allows the program to adjust accordingly if risks become too high or success too unrealistic. Much of the structure for monitoring and evaluating is already in place in Idaho through the Idaho Supplementation Studies (Bowles and Leitzinger 1991) and LSRCP Hatchery Evaluation Study (Cannamela 1993).

IMPLEMENTATION

The underlying premise supporting this approach is that all three groups of fish (natural, supplementation, reserve) returning to upper basin production areas are important to maintain recovery options. If this premise is accepted, we believe this approach is the most logical and effective way to preserve the locally evolved population until mainstem hydrosystem constraints to productivity are remedied and recovery occurs.

For this approach to be feasible and successful, several conditions must be met.

- Ongoing mitigation/compensation programs provide at least a slight adult-to-adult survival benefit over naturally reared fish.
- The natural production area is not currently limited by spawning or rearing habitat.
- External differentiation is possible among natural, supplementation and reserve fish.

- Hatchery and natural fish currently share similar genetic and ecological characteristics.

- Spawning, rearing and release strategies are implemented to minimize risk of inadvertent hatchery selection and domestication, and promote natural behavioral characteristics.

- Intensive monitoring and research is in place to allow individual programs to adjust as uncertainties are resolved and risks identified. This should include:

  - genetic characteristics/profiles of both hatchery groups, natural target fish, and adjacent natural populations;
  - straying rates;
  - temporal and spatial spawning distributions;
  - health status and disease transmission;
  - hatchery/natural interactions;
  - hatchery and natural life history characteristics; and
  - hatchery and natural survival coefficients.

Fish managers in Idaho began recognizing the need to shift to this approach in the late 1980s and are thus in a good position to meet these considerations for all upper basin chinook hatcheries located in critical natural production areas. Ongoing monitoring and research programs are already in place to meet the majority of evaluation requirements. These programs have been designed to provide adequate analytical power to detect adverse effects and allow managers to adjust accordingly.

Scenarios 1 through 3 in Appendix B illustrate hypothetical implementation of this approach to compensation hatchery management within the recovery framework.

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Appendix A. Analysis of chinook escapement before and after hatchery influence to assess benefits from McCall and Sawtooth fish hatcheries.

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February 1, 1993

M E M O R A N D U M

TO: **S.** Kiefer, V. Moore, S. Yundt, D. Pitman, S. Huffaker, B. Hutchinson, T. Rogers, C. Petrosky, D. Anderson, J. Lukens

FROM: Ed Bowles, Paul Sankovich

SUBJECT: Hatchery Benefits Analysis for Section 10 permits

cc: J. Chapman, G. McPherson, B. Bowler, E. Leitzinger, D. Cannamela, R. Kiefer

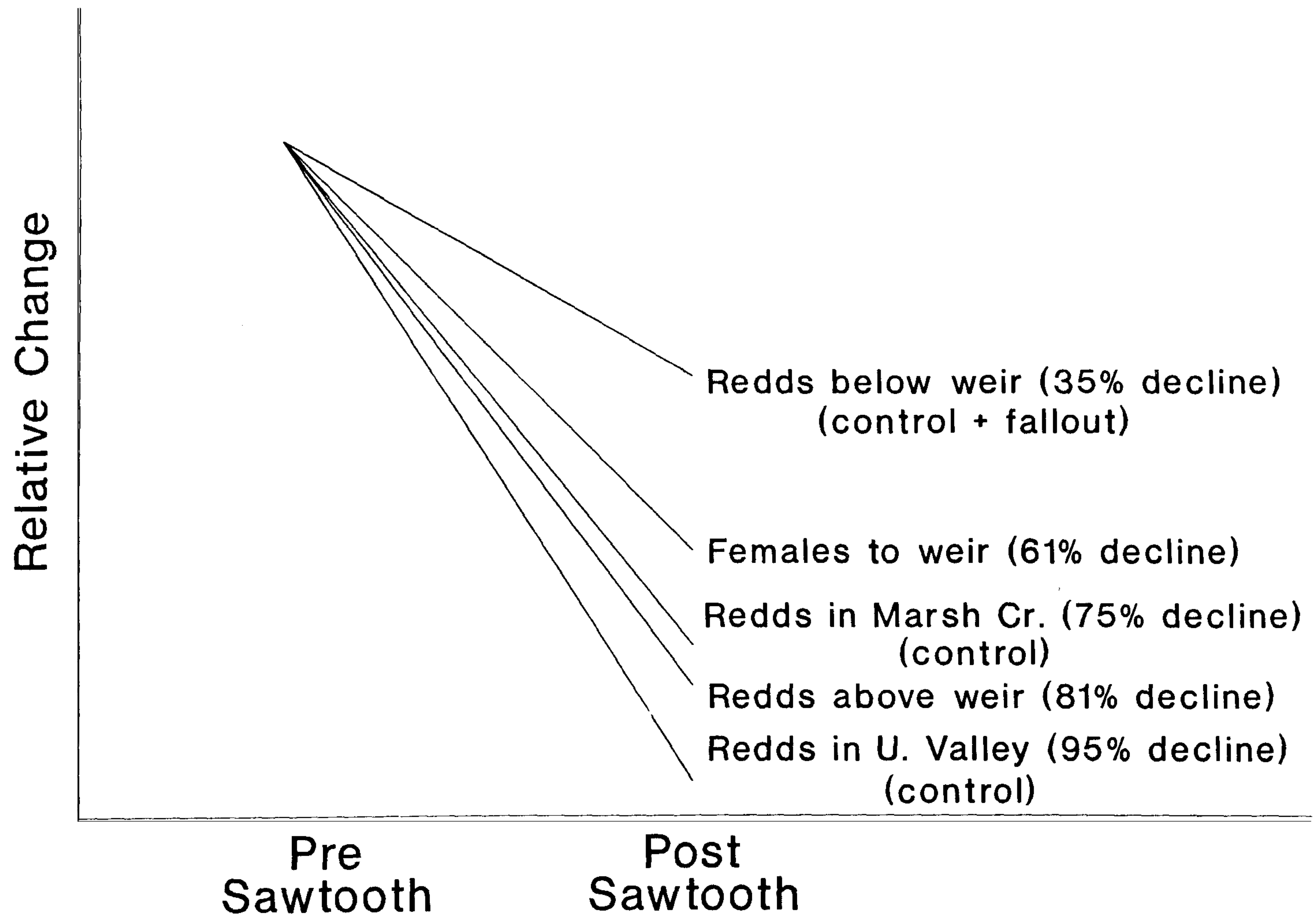
This represents our last look at comparative production trends before and after the Sawtooth and McCall programs came on line. As you recall, our previous analysis was cursory and prepared in response to the Recovery Team's concern about negative hatchery effects. Paul Sankovich and I examined the databases and assumptions more thoroughly for this analysis and came up with essentially the same picture as before.

The information illustrates that Sawtooth and McCall hatcheries have **at least** slowed the decline of total adults produced in the upper Salmon and South Fork Salmon rivers. Interestingly, much of this relative benefit is represented by natural spawning in sections immediately below the weirs. I assume that this is from juvenile "fallout" from natural spawning immediately above the weirs and adult "fallout" from weir effects and smolt releases near the weirs. Regrettably, natural production above the weirs has not increased significantly following hatchery integration. This should not be surprising because dismal return rates for both hatchery and natural fish continue to preclude appreciable recovery of natural fish. On a brighter note, we see no indication that the hatchery programs have contributed to the decline of naturally reproducing salmon.

This analysis is a good approach to assess gross relative changes in production and should be useful in assessing benefits and risks for Section 10 permits. I emphasize, though, that complex inferences are probably inappropriate. The analysis looks only at relative changes in fish numbers (redds or females) and assumes that changes in habitat and general stock productivity characteristics are stable across reaches. The analysis does not directly address other potentially important factors, such as changes in spawning distribution within reaches, age structure, disease carriers and genetics. These may present more chronic impacts than our analysis and database are capable of detecting.

Please let me know if we can assist further.

Comparative Declines in Production
After Sawtooth Hatchery



Explanations of Figure "Comparative Declines in Production after Sawtooth Hatchery"

- *Hatchery benefits to total adult production can be seen in the slower decline in females to the weir, and redds below the weir, relative to redds in Marsh and upper Valley creeks. Because the stock is still operating at below replacement (H & N combined) this benefit has not been translated into increased natural production above the weir yet.*

- Estimates represent mean count before weir (1960-1980) compared to mean count after weir (1981-1992).

- Sawtooth weir was constructed near the middle of one of the redd count trend areas used through 1984. To make useful comparisons above and below the weir, we assumed 15% of the redds counted in that trend area (from 1960-1984) were below the future weir site (K. Ball, IDFG, personal communication). We corroborated this estimate by calculating the proportion of redds upstream (81%) and downstream (19%) of the weir (within the 1960-1984 trend area) in 1985--the first year the 1960-1984 trend area was split into two trend areas. We multiplied the number of redds upstream of the weir by three before calculating the proportions, since only one-third of the females arriving at the weir were released upstream. Hatchery effects on redd distributions should have been minimal in 1985.

- We estimated the number of females returning to the future weir site prior to 1981 by calculating the number of redds above the weir per female released from 1985-1992. We applied this conversion factor to the number of redds upstream of the weir site from 1960-1980 in order to obtain an estimate for the number of females returning to the site before the weir was constructed.

- Marsh Creek and upper Valley Creek probably represent the best controls. Use of Valley Creek is cautioned because bottlenecks resulting from low escapements to upper Valley Creek (mean=9 redds/year counted) might be causing further depression of redd numbers in recent years.

- Redd counts for Marsh Creek include redds in Knapp, Capehorn, and Beaver creeks.

- "Redds below weir" probably represents significant juvenile and adult fallout from the Sawtooth program (i.e. fry/parr produced from redds just above the weir emigrate to, imprint, and return to the section below the weir; a portion of the hatchery juveniles released at the weir imprint on, and return to, the section below the weir; or adults destined for upper reaches spawn below the weir because of weir effects).

– Statistical Comparisons.

  – Marsh Creek (control) was significantly higher ($p=0.011$) than upper Valley Creek (control). We recommend using Marsh Creek as the control for other comparisons because of the extremely low escapements into upper Valley Creek discussed previously.

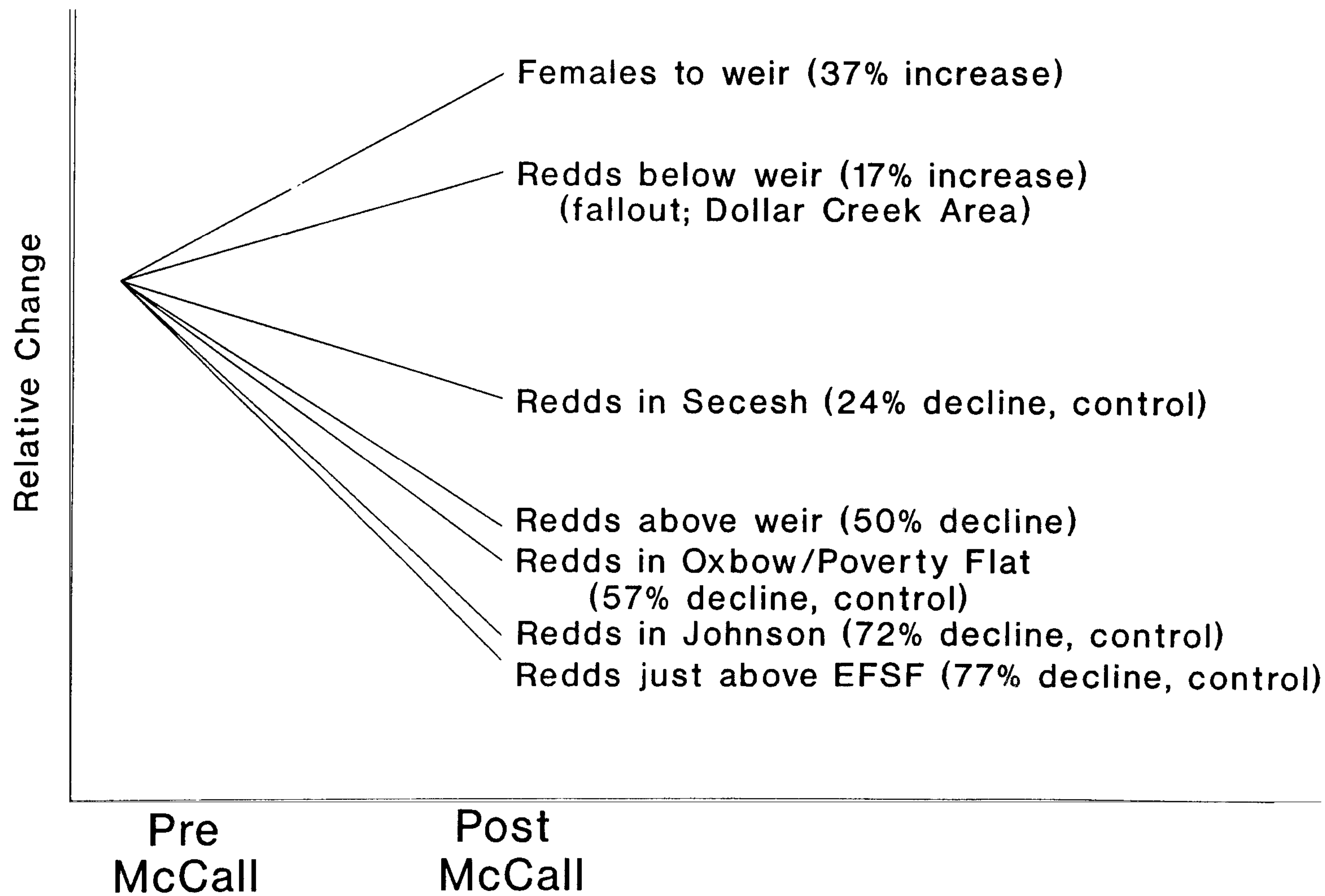
  – The hatchery program has resulted in significantly more ($p=0.000$) redds below the weir (adult and juvenile fallout) than would be expected without the hatchery.

  – Females to the weir ($p=0.142$) and redds above the weir ($p=0.513$) are not significantly different than would be expected without the hatchery.

  – The hatchery program has benefitted relative production below the weir significantly more than relative production to the weir ($p=0.003$) and above the weir ($p=0.000$).

  – The hatchery program has benefitted relative production to the weir significantly more ($p=0.023$) than relative production above the weir. As discussed earlier, one reason natural production above the weir hasn't kept pace is because the entire program (H and N combined) remains below replacement due to excessive smolt-to-adult mortality. Thus the initial "investment" of bringing natural fish into the hatchery has not been "paid back" yet.

Comparative Production
After McCall Hatchery



Explanations of Figure "Comparative Production after McCall Hatchery"

- *The hatchery benefit in total adult production appears strong, even if Secesh/Lake Creek is used for the control. The reason that natural production above the weir hasn't kept pace may be because this increase is still being absorbed primarily to fill the hatchery. If escapements increase to the point that hatchery needs are surpassed, then the 33% ceiling rate for natural production will increase by the surplus (e.g over 50% of adult returns were passed over the weir during 1992).*

- Estimates represent mean count before weir (1960-1979) compared to mean count after weir (1980-1992).

- The South Fork weir was constructed near the upper end of one of the redd count trend areas used from 1960-1983. To make useful comparisons above and below the weir, we assumed no redds were located from the weir site up to that trend area's upper boundary (Knox Bridge) prior to 1985.

- We estimated the number of females returning to the future weir site prior to 1980 by calculating the number of redds above the weir per female released from 1980-1992. We applied this conversion factor to the number of redds upstream of the weir from 1960-1979 in order to obtain an estimate for the number of females returning to the site before the weir was constructed.

- "Redds below the weir" probably represents considerable juvenile and adult fallout from the McCall program (i.e. fry/parr produced from redds just above the weir emigrate to, imprint, and return as adults to the section below the weir; a portion of the hatchery juveniles released at Knox Bridge imprint on, and return to, the section below the weir; or adults destined for upper reaches spawn below the weir because of weir effects). Spawning in this section is concentrated near Dollar Creek, where Don Anderson believes substantial fallout spawning is occurring.

- Redd counts for the Secesh River include redds in Lake Creek.

- Best use of the control streams is open to interpretation; we do not believe sufficient data is available to analyze for possible covariate or confounding factors. The Secesh River/Lake Creek production decline seems low, but it may reflect better habitat conditions because those streams were not part of the blow-out event that occurred in the mid-70's. Chronic habitat effects from this event may continue to be a key factor in Poverty Flats and below.

- Statistical comparisons support what is obvious from the graph.
- No significant difference ($p>0.469$) among three control areas (Oxbow/Poverty Flats, Johnson Creek and SFSR just above the East Fork).
- The Secesh section was slightly higher ($p=0.029$) than the other control sections (pooled).
- If we use Oxbow/Poverty Flats, Johnson, and EFSF sections as controls:
  - Redds below the weir (Dollar Creek; fallout) and females to the weir are significantly higher ($p=0.000$) than would be expected without the hatchery program.
  - Redds above the weir are not significantly different ($p=0.396$) from what would be expected without the hatchery program.
- If the Secesh is used as control:
  - Females to the weir is significantly higher ($p=0.016$) than expected without the hatchery.
  - No significant change in the redds above ($p=0.353$) or redds below ($p=0.164$) the weir can be attributed to the hatchery program.
- There is no significant difference ($p=0.420$) in the effect of the hatchery program on the numbers of redds below the weir vs. females to the weir (i.e. considerable fallout of adults and juveniles).
- Benefits from the hatchery program (in fish numbers) are significantly higher for females to the weir ($p=0.001$) and redds below the weir ($p=0.009$) compared to redds above the weir.

Appendix B. Hypothetical scenarios illustrating management of natural, supplementation, and reserve fish groups returning to compensation hatcheries and natural production areas in Idaho.

Note: Scenarios reflect three levels of current natural variability associated with "system" productivity:

High system productivity represents good flow years, Typical system productivity represents average flow years,
Poor system productivity represents low flow years (e.g., drought).

Parameters used for Modeling Three Production Scenarios

Note: Criteria, thresholds, and capacities are hypothetical and used for illustrative purposes only.

Local Habitat Capacity: 150 k smolts, 870 adults (390 females)
Minimum Threshold-naturally spawning adults: 122 adults (55 females)
Hatchery Straying Threshold: 10% of adjacent local populations
Hatchery Capacity: Original Design- 1,100 k smolts Optimal Smolt Quality- 900 k smolts
Meet Straying Threshold- 800 k smolts (224 adult females)

z 67 % of natural adults allowed to spawn naturally
533 % of natural adults retained for supplementation broodstock z
50% of supplementation broodstock is natural adults 50% of natural broodstock is natural adults

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	Fish Group		
	Hatchery		
	Reserve	Supplementation	Natural
Parameter	430	100	100
Initial Adult Return	4,700	4,700	4,700
Fecundity	10%	10%	10%
% Jacks	50%	50%	50%
% Females without Jacks	5%	5%	5%
Prespawn Mortalities Egg to Smolt	80%	80%	9%
Progeny:Parent Ratio (variable) Average system productivity (typical flow year)	1.1:1	1.1:1	0.9:1
High system productivity (good flow year)	1.3:1	1.3:1	1.1:1
Low system productivity (poor flow year)	0.8:1	0.8:1	0.6:1
Smolt to Adult (variable) Average system productivity	0.07%	0.07%	0.50%
High system productivity	0.08%	0.08%	0.60%
Low system productivity	0.05 %	0.05 %	0.33 %

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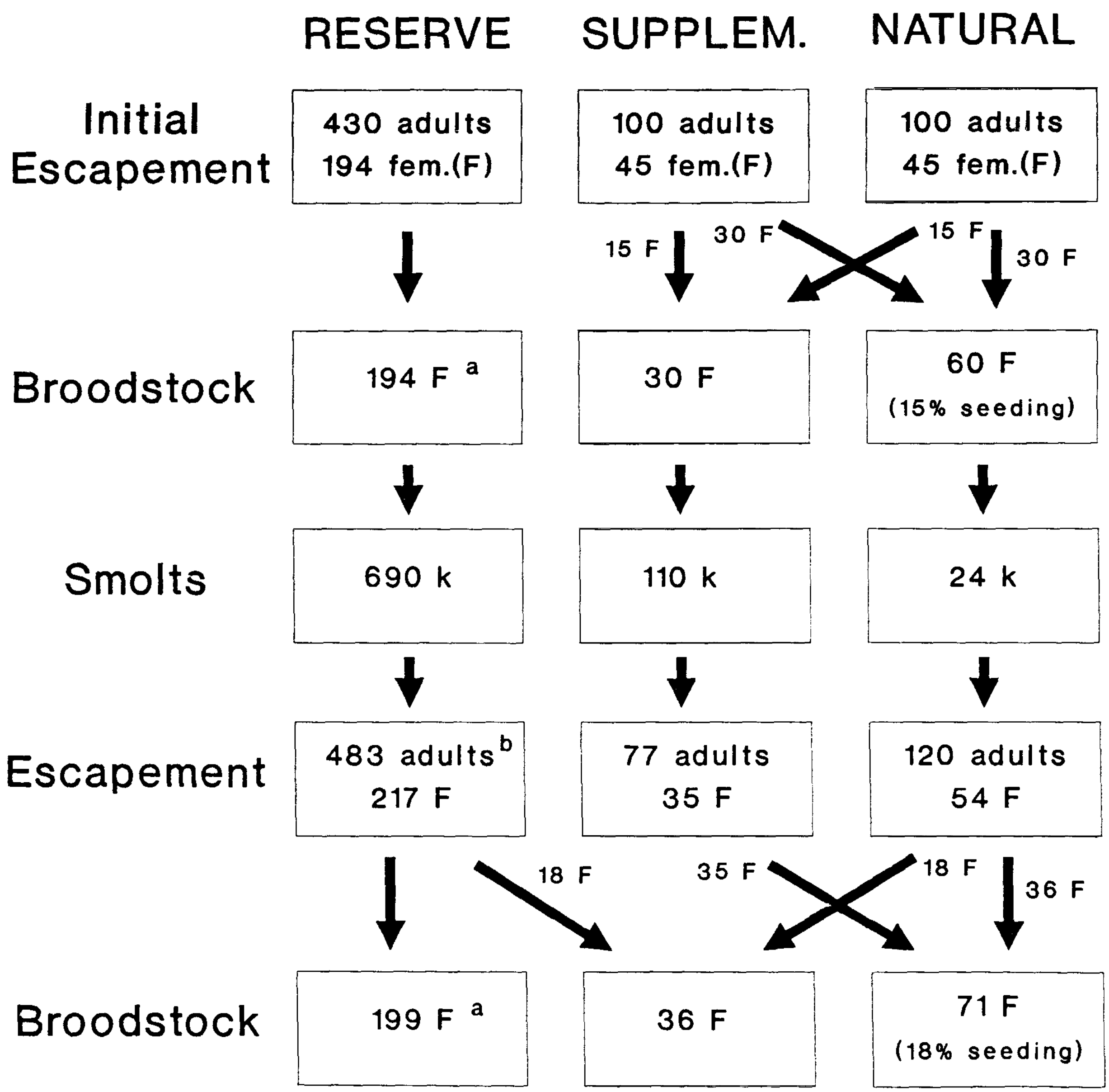
HYPOTHETICAL SCENARIO 1

Mid range of current system productivity, with natural fish slightly below replacement levels and hatchery fish slightly above replacement. Supplementation increases natural production by 60%. Reserve bank is used to augment supplementation broodstock. Harvest is not required to manage reserve fish escapement.

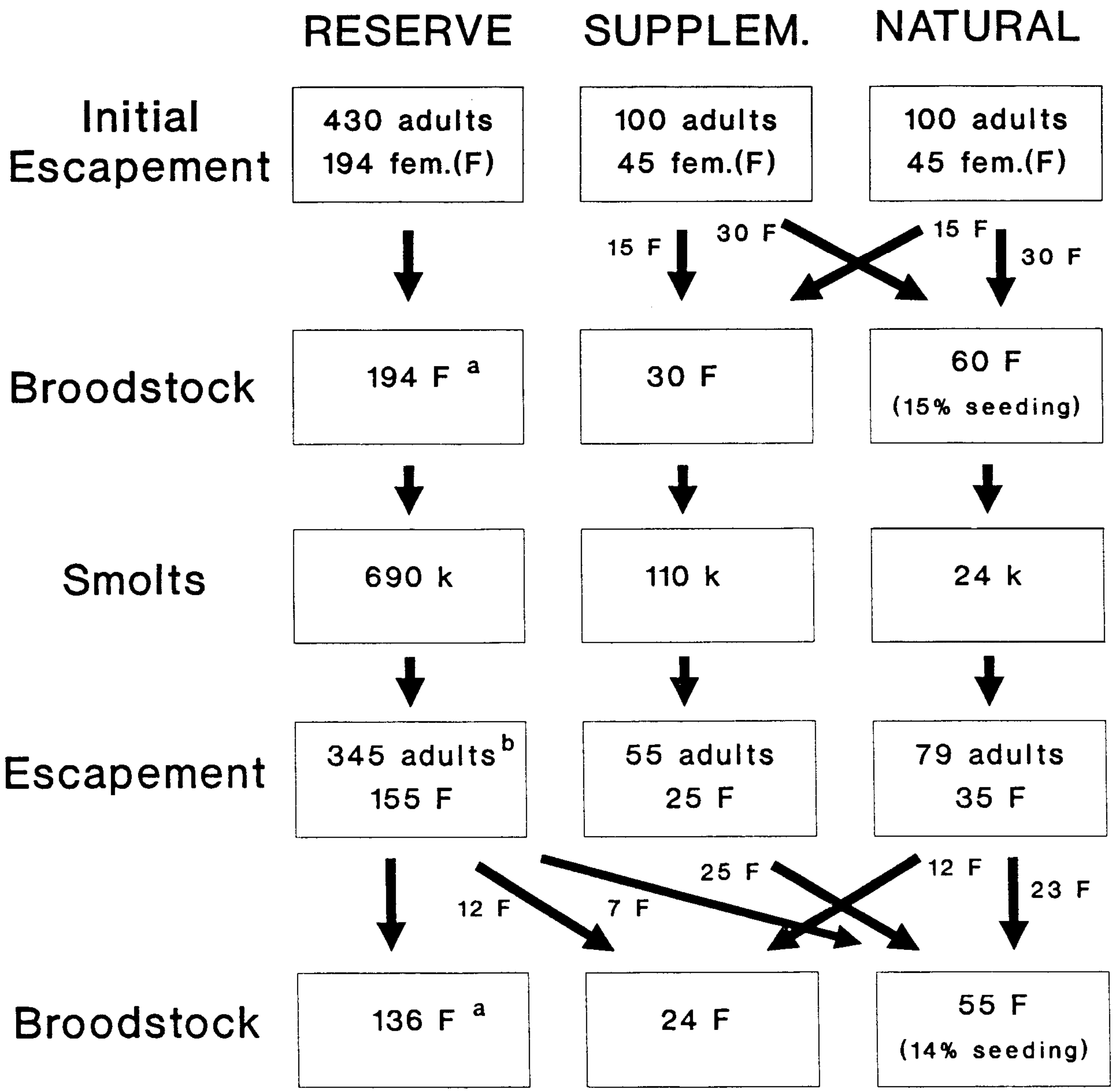


[a]Utilize partial spawn from natural males in supplementation broodstock

[b]Surplus (24 adults) well within likely predictor confidence limits. Therefore, harvest not anticipated for control of escapement

HYPOTHETICAL **SCENARIO** 2

Low range of current system productivity, with natural fish well below replacement levels and hatchery fish slightly below replacement. Supplementation increases natural production by 20%. Reserve bank Is used to augment supplementation broodstock and maintain number of naturally spawning fish above critical threshold (55 females), Harvest is not required to manage reserve fish escapement.

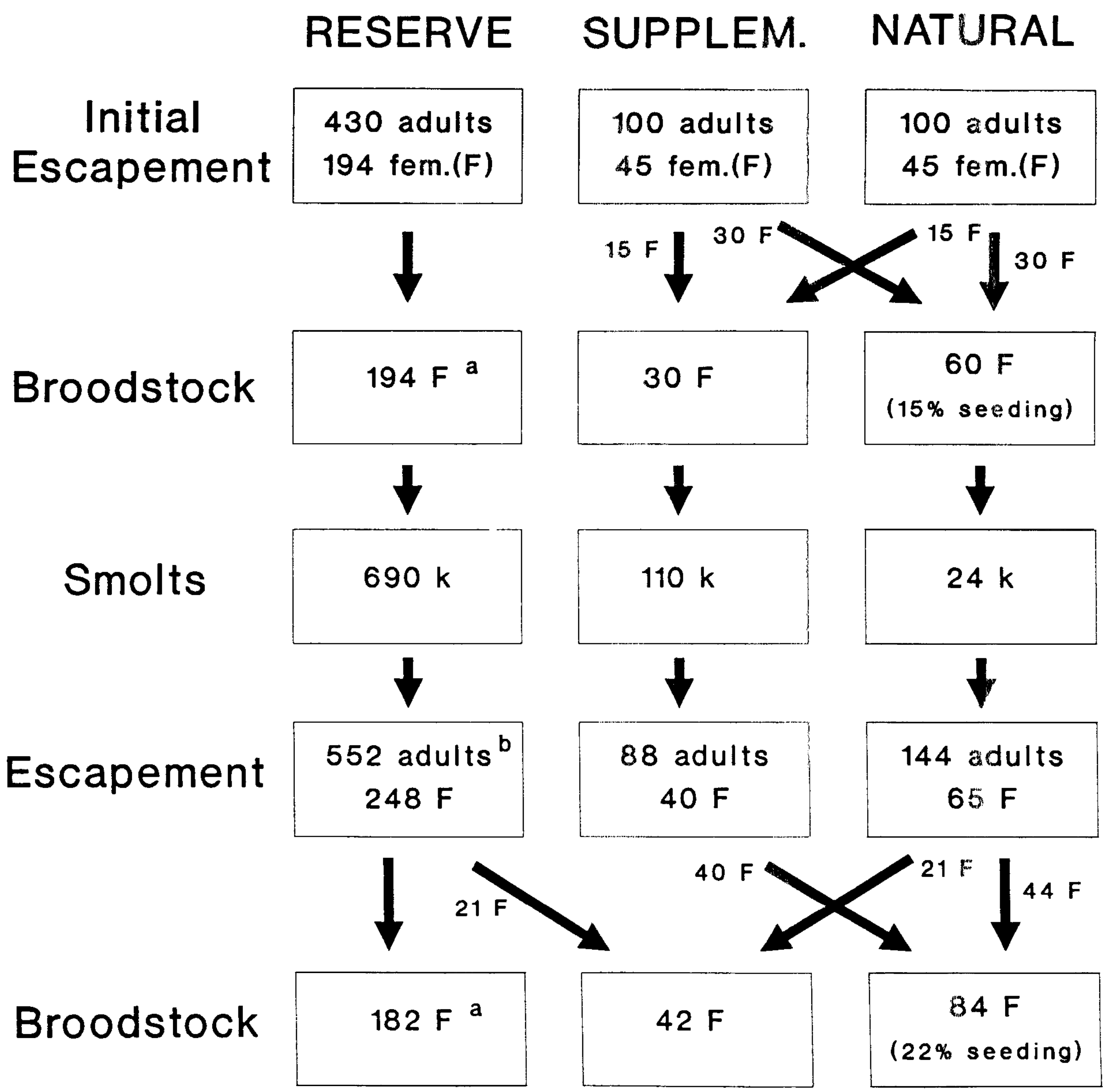


[a] Utilize partial spawn from natural males in supplementation broodstock

[b] No harvest required to control escapement of reserve fish
(150 adult deficit for hatchery rearing target).

HYPOTHETICAL SCENARIO 3

High range of current system productivity, with natural fish slightly above replacement levels and hatchery fish well above replacement. Supplementation increases natural production by 70%, Reserve bank is used to augment supplementation broodstock. Harvest is required to manage reserve fish escapement.



[a] Utilize partial spawn from natural males in supplementation broodstock

[b] Harvest of 150 adults to control escapement of reserve fish.